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(54) **ELECTRONIC SYSTEM WITH DATA MANAGEMENT MECHANISM AND METHOD OF OPERATION THEREOF**

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None
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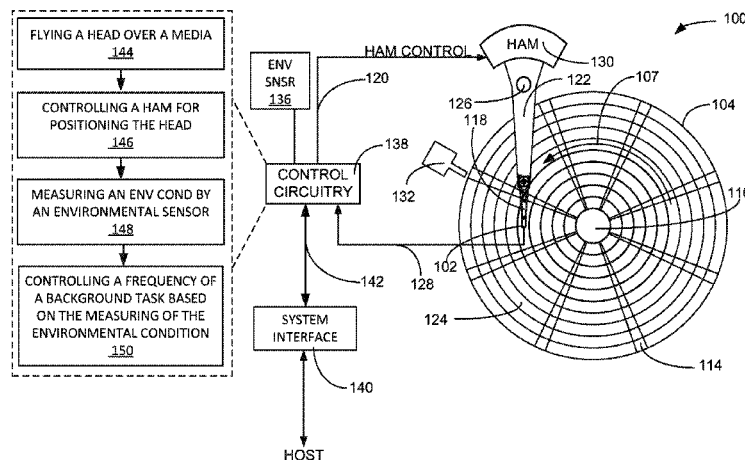
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(57) **ABSTRACT**

An apparatus includes: a media; a head over the media; a head actuation motor coupled to the head; control circuitry, coupled to the head actuation motor, configured to position the head; and an environmental sensor, coupled to the control circuitry, configured to measure an environmental condition; wherein the control circuitry is further configured to: perform a background task; and adjust a frequency of the background task based on the magnitude of the environmental condition.

35 Claims, 5 Drawing Sheets



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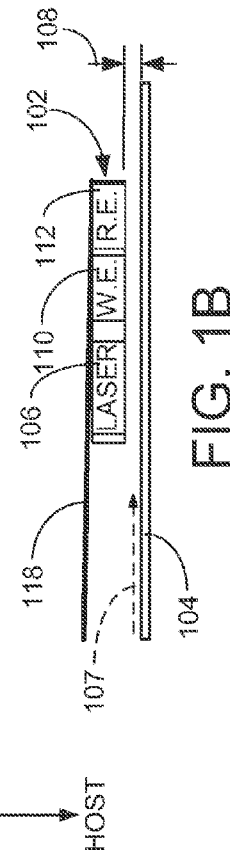
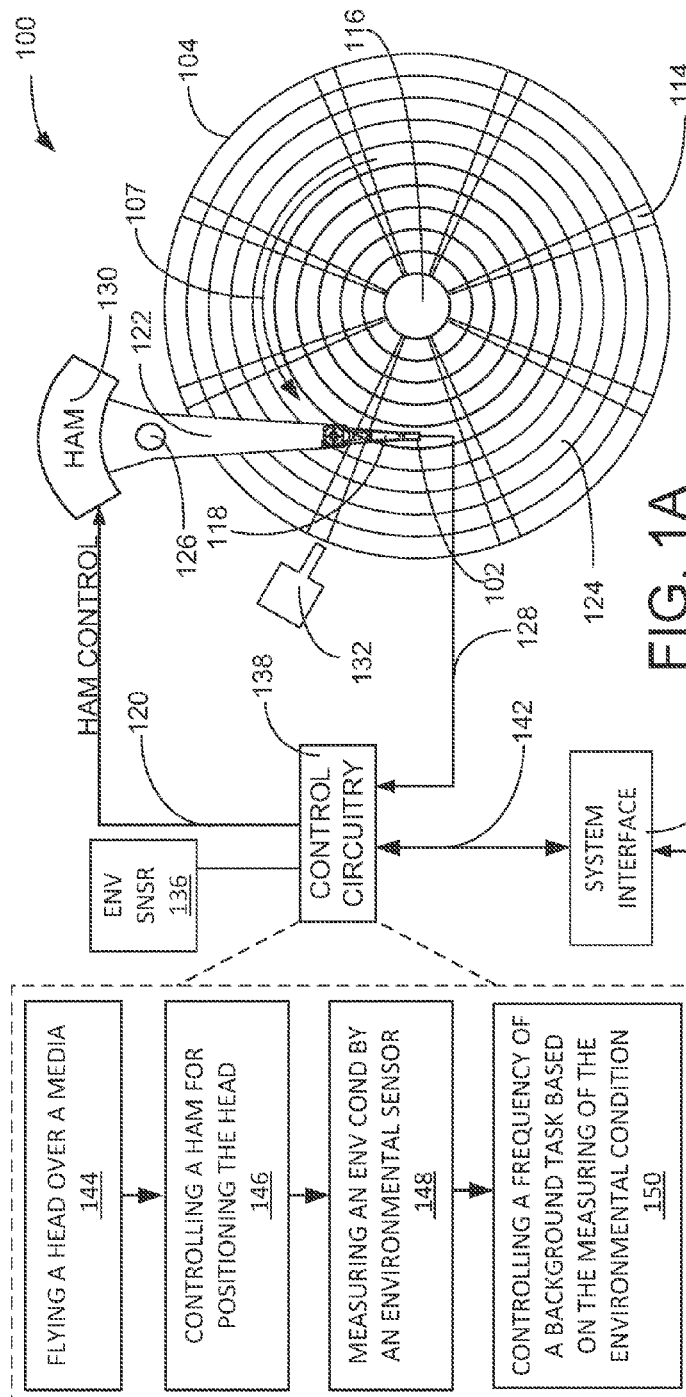


FIG. 1C

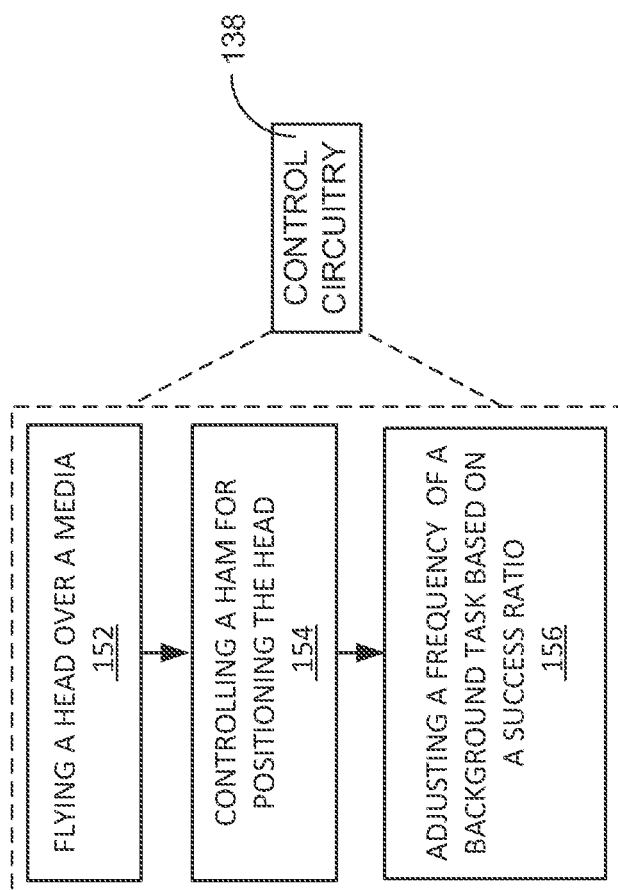
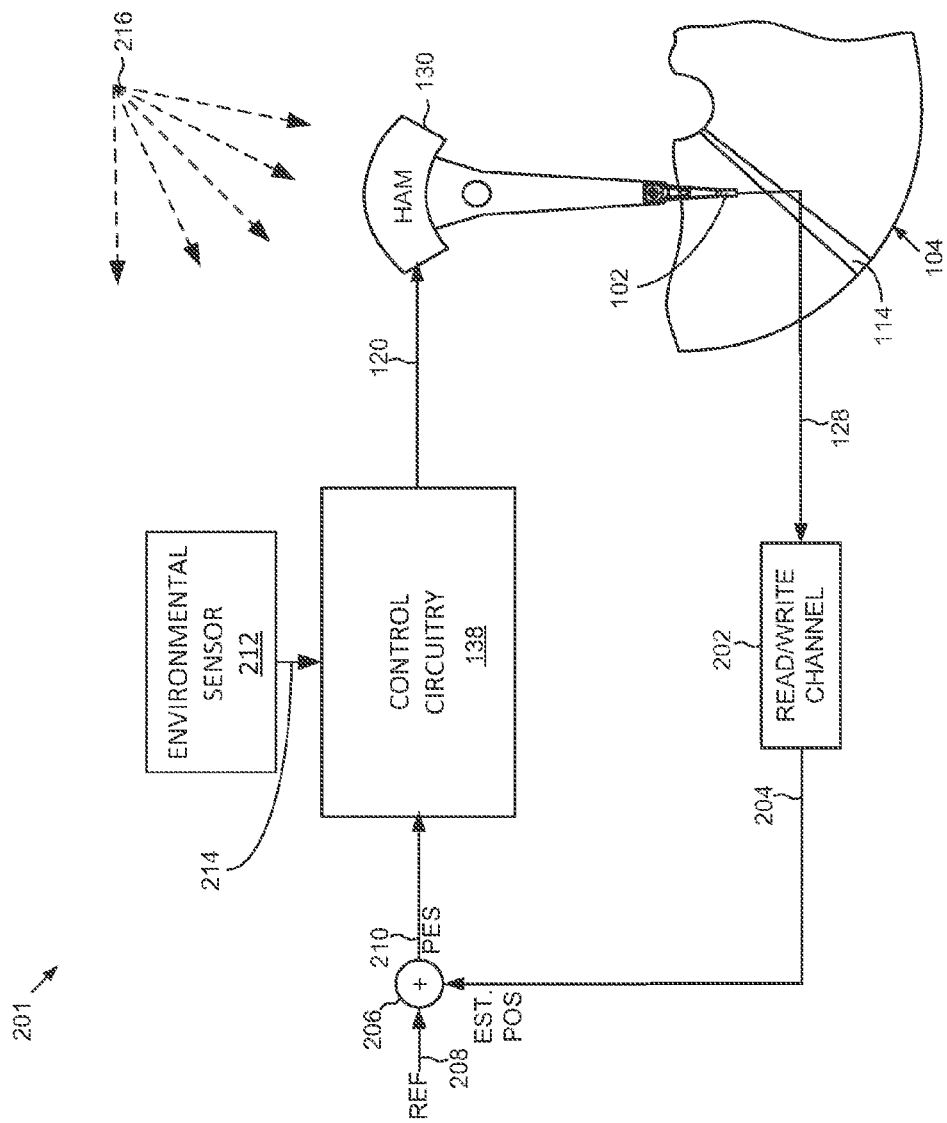


FIG. 1D



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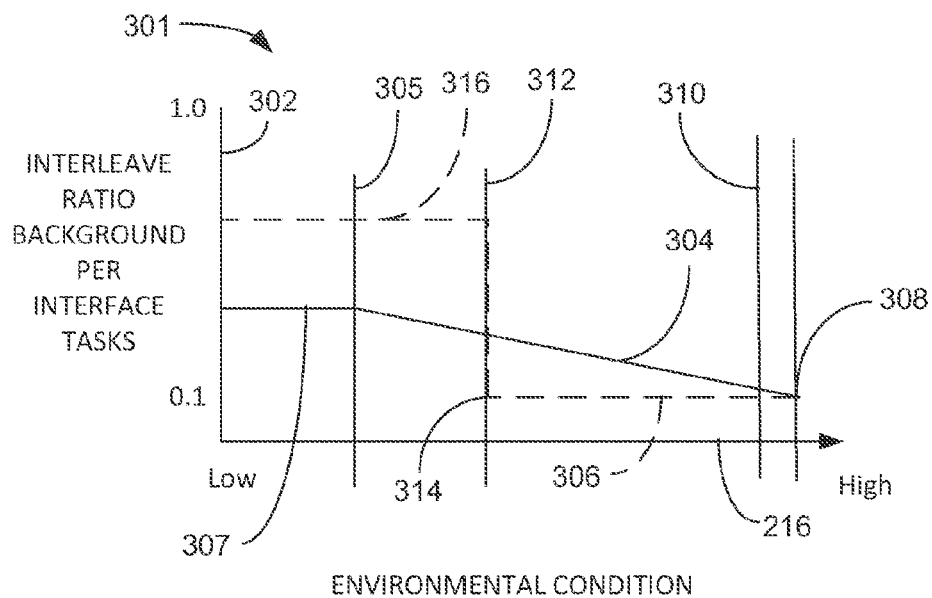


FIG. 3

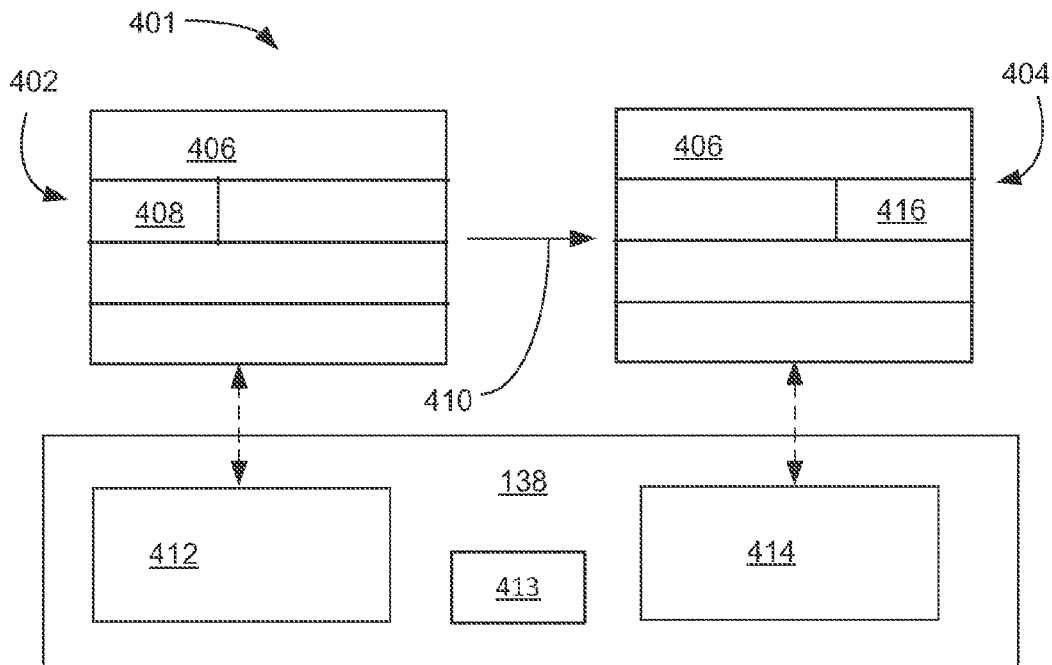


FIG. 4

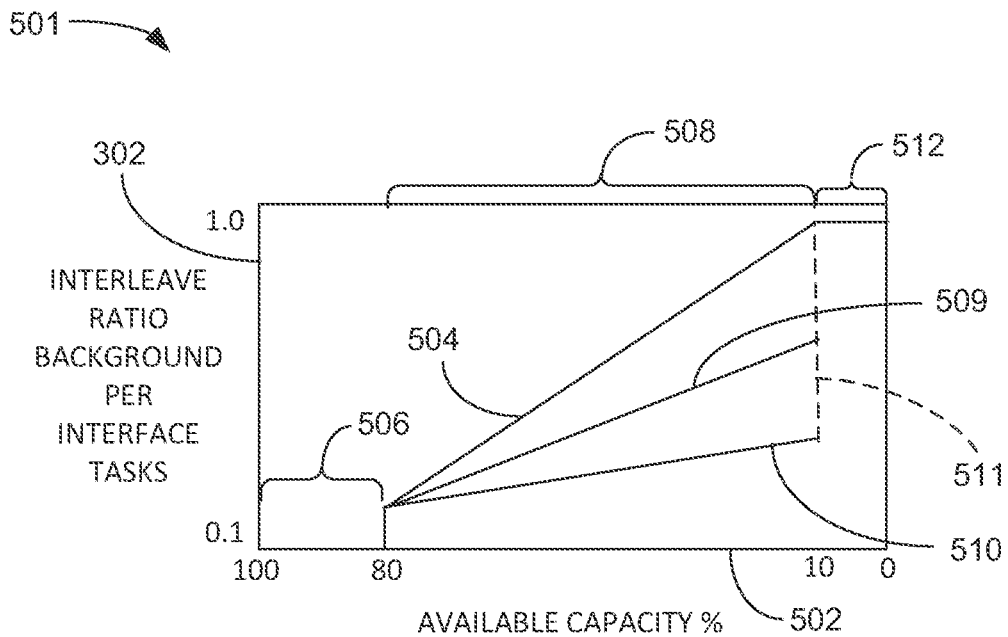


FIG. 5

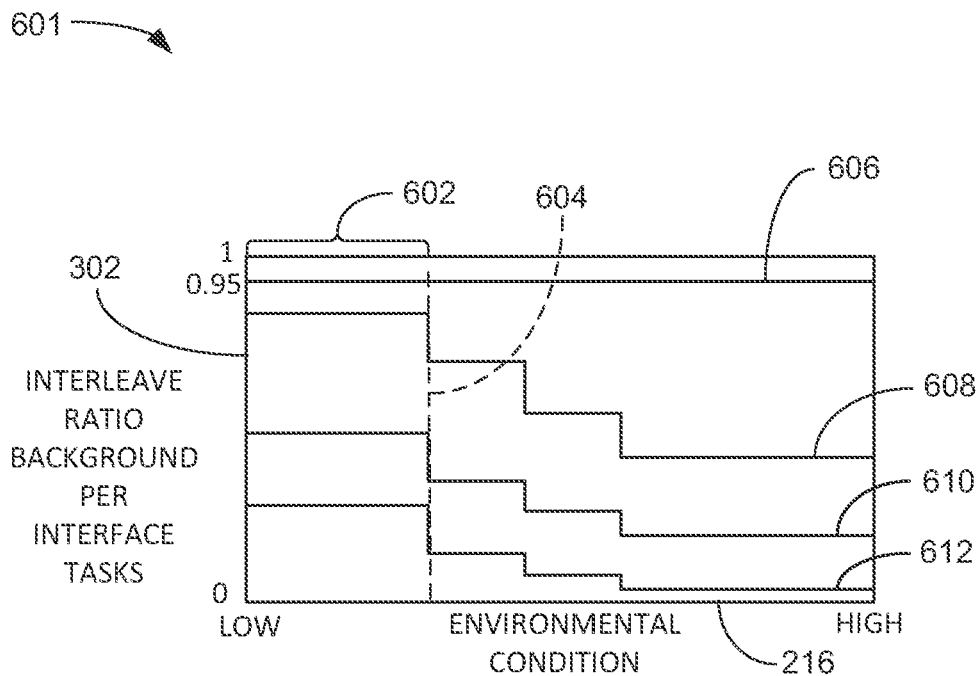


FIG. 6

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ELECTRONIC SYSTEM WITH DATA MANAGEMENT MECHANISM AND METHOD OF OPERATION THEREOF

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/991,341 filed May 9, 2014, and the subject matter thereof is incorporated herein by reference thereto.

TECHNICAL FIELD

An embodiment relates generally to an electronic system, and more particularly to a system for data management.

BACKGROUND

Modern consumer and industrial electronic devices require storage of information, such as digital photographs, electronic mail, calendar, or contacts. These devices can be electronic systems, such as notebook computers, desktop computers, servers, televisions, and projectors, and are providing increasing levels of functionality to support modern life. Preserving the user data stored in the storage devices is of the utmost importance.

As recording technologies advance in hard disk drives, the Tracks-Per-Inch (TPI) has increased. This has become increasingly challenging to maintain the writer element over the center of the track as the tracks have become closer together. Protecting adjacent tracks from corruption from the current track writing operation is one of the most important reasons to keep the writer element over the center of the track

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, 1C, and 1D show an operational diagram of an electronic system with data management according to an embodiment.

FIG. 2 shows a servo control system, of the electronic system 100, for controlling a frequency of background tasks in the presence of environmental conditions, in accordance with an embodiment.

FIG. 3 provides a line graph of performance of an embodiment of a data management system for managing background tasks in the presence of environmental conditions.

FIG. 4 shows an exemplary block diagram of an apparatus configured to perform a background task in an embodiment.

FIG. 5 shows a line graph of performance of an embodiment of a data management system for managing background tasks based on the available capacity percentage.

FIG. 6 shows a line graph of the interleave ratio of the background tasks to interface tasks in the presence of environmental conditions.

DETAILED DESCRIPTION

Storage systems can include storage devices, such as hard disk drives (HDD) and hybrid drives utilizing shingle magnetic recording (SMR) heads, manage the capacity utilization during writes. In order to maintain data integrity many of the storage devices perform off-line or background tasks, such as garbage collection (GC), file defragmentation, or data reliability verification, that concentrate the written data into a smaller sector space than it was originally written. These processes can be interleaved with interface tasks (e.g., opera-

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tions generated via commands received through a host interface) in order to minimize the latency seen by the storage system host. By way of an example, the GC tasks can be interleaved at a rate of 1 background task per 10 interface tasks.

Under an external vibration environment, staying over the center of the track becomes more difficult. As an example, the position of the write element can be sampled and when a sample is greater than a threshold distance from the track center, the write operation is aborted. As the vibration level increases, the abort occurrence rate increases.

In a system with limited in-place retries, the write operations continue after repositioning the write element further down the shingled track or on a non-shingled track. This wastes the intervening space and increases the background tasks.

In a system that has a verify task after a write operation of data, a verify failure can cause a re-write of data after repositioning the write element further down the shingled track or on a non-shingled track. This also wastes the intervening space and reduces the efficiency of the background tasks.

If the inefficiency reduces to a point where the amount of wasted space that is greater than the amount of consolidated free space that is created then the GC task causes an increase in urgency instead of a decrease in urgency. If left unchecked this could cause the drive to become inoperable.

Some embodiments modify the urgency and the aggressiveness of background tasks, such as garbage collection, based on the current vibration level at the drive. As the vibration level at the drive increases, the urgency of the background tasks can be relaxed. As the vibration level decreases, the urgency level for the activities can increase in order to reduce the backlog of operations needed to keep usable capacity in balance. The manipulation of the urgency in preparation for times of higher vibration can be implemented by changing the interleave ratio between the background tasks and interface tasks.

It is understood that the background tasks are initiated and managed within the electronic system. The interface tasks differ from the background tasks because all interface tasks are initiated by the host system and transferred through the system interface.

A need still remains for an electronic system as an embodiment with data management mechanism for managing the urgency of background tasks. In view of the ever-increasing commercial competitive pressures, along with growing consumer expectations and the diminishing opportunities for meaningful product differentiation in the marketplace, it is increasingly critical that answers be found to these problems. Additionally, the need to reduce costs, improve efficiencies and performance, and meet competitive pressures adds an even greater urgency to the critical necessity for finding answers to these problems.

Solutions to these problems have been long sought but prior developments have not taught or suggested any solutions and, thus, solutions to these problems have long eluded those skilled in the art.

Certain embodiments have other steps or elements in addition to or in place of those mentioned above. The steps or elements will become apparent to those skilled in the art from a reading of the following detailed description when taken with reference to the accompanying drawings.

The following embodiments are described in sufficient detail to enable those skilled in the art to make and use the various embodiments. It is to be understood that other embodiments would be evident based on the present disclo-

sure, and that system, process, or mechanical changes may be made without departing from the scope of an embodiment.

In the following description, numerous specific details are given to provide a thorough understanding of the various embodiments. However, it will be apparent that the various embodiments can be practiced without these specific details. In order to avoid obscuring an embodiment, some well-known circuits, system configurations, and process steps are not disclosed in detail.

The drawings showing embodiments of the system are semi-diagrammatic, and not to scale and, particularly, some of the dimensions are for the clarity of presentation and are shown exaggerated in the drawing figures. Similarly, although the views in the drawings for ease of description generally show similar orientations, this depiction in the figures is arbitrary for the most part. Generally, the various embodiments can be operated in any orientation. The various embodiments have been numbered first embodiment, second embodiment, etc. as a matter of descriptive convenience and are not intended to have any other significance or provide limitations for an embodiment.

Referring now to FIGS. 1A, 1B, 1C, and 1D, therein are shown an operational diagram of an electronic system 100 according to an embodiment. The electronic system 100 can represent an apparatus for one of the various embodiments. Various embodiments can include the embodiment depicted in FIGS. 1A, 1B, 1C, and 1D which by way of an example is shown as a hard disk drive although it is understood that the electronic system 100 can be a tape drive, a solid-state hybrid disk drive, or other magnetic media-based storage device. Further for example, the electronic system 100 can represent a desktop computer, a notebook computer, a server, a tablet, a television, a household appliance, or other electronic systems utilizing magnetic media storage.

The electronic system 100 including a head 102 actuated over a media 104. The head 102 can be mounted to a flex arm 118 attached to an actuator arm 122. The head 102 (FIG. 1B) can optionally include a laser 106 for heating the media 104 during part of a write process (e.g., the head is part of an Energy-Assisted Magnetic Recording (EAMR) drive). The flying height 108 can be adjusted (e.g., by use of a heater element in the head not shown in FIG. 1B) while writing data to the media 104 or as an error recovery process during reading from the media 104. Also in an embodiment of FIG. 1B, the head 102 comprises a write element 110 (e.g., an inductive coil) and a read element 112 (e.g., a magnetoresistive read element).

The media 104 is a structure for storing information on data tracks 124. For example, the media 104 can be made of an aluminum alloy, ceramic/glass, or a similar non-magnetic material. The top and bottom surfaces of the media 104 can be covered with magnetic material deposited on one or both sides of the media 104 to form a coating layer capable of magnetization. As an example, the media 104 can be a disk platter for one embodiment of the electronic system 100 as a rotating storage system, such as a hard disk drive (HDD). As a further example, the media 104 can be a linear magnetic strip for one embodiment of the electronic system 100 as a linear storage system, such as a tape drive.

The laser 106, as an example, can be a laser diode or other solid-state based lasers. In addition, embodiments can employ any suitable techniques for focusing the laser 106 on the media 104, such as a suitable waveguide, magnifying lens, or other suitable optics. The laser 106 is increased to a write power in order to heat the disk, thereby decreasing the coercivity of the media 104 so that the data is written more reliably on the data tracks 124.

The spindle motor 116 can rotate the media 104, about a center of the media 104, at constant or varying speed 107. For illustrative purposes, the spindle motor 116 is described as a motor for a rotation, although it is understood that the spindle motor 116 can be other actuating motors for a tape drive, as an example.

As examples, a head actuation motor 130 can be a voice coil motor assembly, a stepper motor assembly, or a combination thereof. The head actuation motor 130 can generate a torque or force for positioning the head 102. An environmental sensor 136 can detect and measure any environmental disturbance that can affect the positioning of the head 102.

A tapered end of the flex arm 118 can support the head 102. The flex arm 118 can be mounted to the actuator arm 122, which is pivoted around a bearing assembly 126 by the torque generated by the head actuation motor 130. The head 102 can include a single instance of the write element 110 and a single instance of the read element 112 that is narrower than the write element 110. The head 102 can fly over the media 104 at a dynamically adjustable span of the flying height 108, which represents a vertical displacement between the head 102 and the media 104. The head 102 can be positioned by the flex arm 118 and the actuator arm 122 and can have the flying height 108 adjusted by control circuitry 138. The control circuitry 138 can measure a magnitude of the environmental disturbance, through the environmental sensor 136, and calculate a feed forward adjustment for the head actuation motor 130.

The head 102 can be positioned over the media 104 along an arc shaped path between an inner diameter of the media 104 and outer diameter of the media 104. For illustrative purposes, the actuator arm 122 and the head actuation motor 130 are configured for rotary movement of the head 102. The actuator arm 122 and the head actuation motor 130 can be configured to have a different movement. For example, the actuator arm 122 and the head actuation motor 130 could be configured to have a linear movement resulting in the head 102 traveling along a radius of the media 104.

The head 102 can be positioned over the media 104 to create magnetic transitions or detect magnetic transitions from the data tracks 124 recorded in the coating layer that can be used to representing written data or read data, respectively. The position of the head 102 and the speed 107 of the media 104 can be controlled by the control circuitry 138. Examples of the control circuitry 138 can include a processor, an application specific integrated circuit (ASIC) an embedded processor, a microprocessor, a hardware control logic, a hardware finite state machine (FSM), a digital signal processor (DSP), digital circuitry, analog circuitry, optical circuitry, or a combination thereof. The control circuitry 138 can also include memory devices, such as a volatile memory, a non-volatile memory, or a combination thereof. For example, the nonvolatile storage can be non-volatile random access memory (NVRAM) or Flash memory and a volatile storage can be static random access memory (SRAM) or dynamic random access memory (DRAM).

A system interface 140 can couple the control circuitry 138 to a host electronics (not shown). The system interface 140 can transfer interface tasks 142 between the host electronics and the control circuitry 138. The interface tasks 142 can be encoded or decoded by the control circuitry 138 in preparation for transfer to or from the media 104.

The control circuitry 138 can be configured to control the spindle motor 116 for adjusting the speed 107 of the media 104. The control circuitry 138 can be configured to cause the head 102 to move relative to the media 104, or vice versa. The control circuitry 138 can be configured to control the speed 107 of the media 104 and the position of the head 102 by

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reading servo sectors **114** strategically placed on the media **104**. The servo sectors **114** can be recorded on the media **104** during a manufacturing process. The control circuitry **138** can also be configured to control the flow of information to the head **102** for writing to the media **104**. The information sent to the head **102** can include the preconditioning pattern, direct current erase signals, user data, or a combination thereof. The control circuitry **138** can retrieve the recorded information and monitor the servo sectors **114** through a read signal **128** provided by the head **102**.

In an embodiment, the electronic system **100** further comprises control circuitry **138** configured to execute the flow diagrams of FIG. **1C**. As an example, actions **144** to **150** can represent the flow diagram where an embodiment is employing a data management mechanism for maintaining data integrity.

In an action **144**, the head **102** is flown over the media **104** during execution by the electronic system **100**, such as a manufacturing test fixture, a hard disk drive, a tape drive, or a hybrid drive.

In an action **146**, the control circuitry can control the position of the head by monitoring the servo information detected by reading the servo sectors. The control circuitry **138** can detect the actual position of the head relative to the intended position of the head by monitoring a position error signal (PES).

In an action **148**, an environmental condition, such as an environmental vibration, can be measured during execution by the electronic system **100**. The relative strength of the environmental condition can be determined by analysis of the PES. In background tasks, such as garbage collection, file defragmentation, an excessive amount of position error will cause a decrease in packing density and result in little or no release of wasted capacity.

In an action **150**, the control circuitry can control a frequency of the background task based on the measuring of the environmental condition. For example, frequency can be adjusted by controlling the execution interleave ratio as compared to the interface tasks. By way of an example, the background task interleave ratio can be running at one background task to 10 interface tasks. After the environmental vibration has passed, the urgency of the background task can be increased beyond where had previously been running. The increased urgency can, for example, increase the interleave ratio to five background tasks to 10 interface tasks. This increase in the interleave ratio can help to catch-up with the backlog of work that was created by reducing the frequency of the background task.

In an embodiment, the electronic system **100** further comprises control circuitry **138** configured to execute the flow diagrams of FIG. **1D**. As an example, actions **144** to **150** can represent the flow diagram where an embodiment is employing a data management mechanism for maintaining data integrity.

In an action **152**, the head **102** is flown over the media **104** during execution by the electronic system **100**, such as a manufacturing test fixture, a hard disk drive, a tape drive, or a hybrid drive.

In an action **154**, the control circuitry can control the position of the head by monitoring the servo information detected by reading the servo sectors. The control circuitry **138** can detect the actual position of the head relative to the intended position of the head by monitoring a position error signal (PES).

In an action **156**, an environmental condition, such as an environmental vibration, can be measured during execution by the electronic system **100**. The relative strength of the

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environmental condition can be determined by analysis of the PES. In background tasks, such as garbage collection, file defragmentation, an excessive amount of position error will cause a decrease in packing density and result in little or no release of wasted capacity.

In an action **158**, the control circuitry can calculate a success ratio for controlling a frequency of the background task based on the magnitude of the environmental condition. For example, frequency can be adjusted by controlling the execution interleave ratio as compared to the interface tasks. After the environmental vibration has passed, the urgency of the background task can be increased beyond where had previously been running. The increased urgency can, for example, increase the interleave ratio to five background tasks to 10 interface tasks. This increase in the interleave ratio can help to catch-up with the backlog of work that was created by reducing the frequency of the background task.

It has been discovered that an embodiment of the electronic system **100** can improve the overall performance. The electronic system **100** can balance interface tasks and background tasks in order to maintain the optimum capacity and performance of the interface tasks.

Referring now to FIG. **2**, therein is shown a servo control system **201**, of the electronic system **100**, for controlling a frequency of background tasks in the presence of environmental conditions, in accordance with an embodiment. The servo control system **201** for controlling the head actuation motor **130** in order to position the head assembly **102** radially over the media **104**. A read/write channel **202** demodulates the read signal **128** into an estimated position **204** for the head assembly **102** relative to the data track **124** of FIG. **1A** on the media **104**. The estimated position **204** is applied to a first adder **206** for subtracting a reference position **208** in order to generate a position error signal (PES) **210**. The control circuitry **138** can monitor the output of an environmental sensor **212** for adjusting the response to the PES **210** in order to generate the HAM control signal **120**.

It has been discovered that an environmental condition magnitude **214** of an environmental condition **216**, such as an environmental vibration, a periodic shock, or an acoustic pressure wave can be monitored by the environmental sensor **212**. A magnitude of the environmental condition **216** can be monitored by the control circuitry **138** for generating the HAM control signal **120** to prevent large tracking errors normally observed when the environmental condition magnitude **214** increases the magnitude of the PES **210**. The control circuitry **138** can also manage the execution of background tasks, such as garbage collection, file defragmentation, data compression, data encryption, or a combination thereof based on thresholds established for the environmental condition magnitude **214** of the environmental condition **216**.

The execution of the background tasks can be controlled by the control circuitry **138** based on the magnitude of the PES **210**, analysis of the rate of change of the PES **210** or the environmental condition magnitude **214** of the environmental condition **216**, the available capacity of the media **104** of FIG. **1A** representing the unused portion of the media **104**, the magnitude of the environmental condition magnitude **214** of the environmental condition **216**, or a combination thereof. The control circuitry **138** can calculate a success ratio for the completion of the background tasks as compared to the environmental condition magnitude **214** of the environmental condition **216**, the PES **210**, or a combination thereof.

The control circuitry **138** can calculate the success ratio based on the space consumed (or rate of space consumed) by the background tasks as compared to the environmental condition magnitude **214** of the environmental condition **216**, the

PES 210, or a combination thereof. The control circuitry 138 can determine the space consumed by monitoring the number of sectors, within the data tracks 124, which are skipped or terminated while writing due to the PES 210 or the environmental condition magnitude 214 of the environmental condition 216 exceeding a threshold for that operation. The threshold can be based on the relative position of the head 102 and the center of the data tracks 124, a change magnitude of the PES 210 or the environmental condition magnitude 214 of the environmental condition 216, or a combination thereof. The control circuitry 138 can utilize historical trends to dynamically adjust the thresholds applied to the PES 210, the environmental condition magnitude 214 of the environmental condition 216, or the combination thereof.

The control circuitry 138 can be configured to monitor the available capacity of the media 104 and the amount of space that is consumed or freed by the execution of the background tasks. In general the execution of the background tasks can increase the available capacity, improve the placement of file fragments, identify bad spots in the media 104, or a combination thereof. When the environmental condition magnitude 214 of the environmental condition 216 increases in magnitude, the execution of the background tasks can consume more space than is freed back to the usable capacity of the media 104.

The control circuitry 138 can be configured to calculate the success ratio based in part by the number of sectors, within the data tracks 124, which are freed by the execution of the background tasks. In some instances, the control circuitry 138 can be configured to calculate the success ratio based in part on the rate of the sectors freed by the background tasks. The control circuitry 138 can utilize the success ratio as calculated to control the frequency of the background tasks relative to the execution of host commands delivered through the system interface 140 of FIG. 1A. By way of an example, the control circuitry 138 can utilize the success ratio to determine an increase threshold and a decrease threshold to adjust the frequency of the background tasks relative to the host commands. In some severe instances, the control circuitry 138 can calculate an abort threshold, to temporarily halt the background tasks, based on the PES 210, the environmental condition magnitude 214 of the environmental condition 216, or a combination thereof.

Referring now to FIG. 3, therein is shown a line graph of performance of an embodiment of a data management system for managing background tasks in the presence of environmental conditions.

An embodiment monitors the amount of free space that can be consolidated during the background tasks and also monitors the amount of free space consumed by the background tasks. When the electronic system 100 is subjected to environmental condition magnitude 214 of the environmental condition 216 of FIG. 2 there is an increased possibility that the background tasks can consume more space than they can release. An embodiment detects this condition and suspends the background tasks until such time as the vibration environment decreases to a level considered more suitable for GC operations.

When the environmental condition magnitude 214 of the environmental condition 216 decreases to this level, the background tasks can recommence. An embodiment provides a mechanism that keeps a production read counter of data skipped (invalid sectors) or read (valid sectors) from the source zone of the background tasks. There can be another counter of the sectors consumed in the destination zone written to by the background tasks. The consumed sectors can be data successfully written or sectors skipped due to too many

write abort events or a verify failure of that sector. When the consumption counter is greater than the production counter, the background tasks have lost efficiency and are consuming space faster than it is freeing space. This is a bad situation and is counterproductive to the purpose of the background tasks. A threshold could be used and compared against the over consumption of space relative to production and shut down the background tasks.

In one embodiment, this system assumes environmental condition is the cause of the degradation of the background tasks. When this event occurs, the environmental condition can be measured and then subsequently monitored. When the environmental condition magnitude 214 of the environmental condition 216 decreases below the level that caused the background tasks ceasing then the background tasks can be resumed. As an example, a minimum reduction of the environmental condition magnitude 214 of the environmental condition 216 can be required to reduce the likelihood of toggling back and forth between the two the background task states (hysteresis can be used).

As shown in FIG. 3, an embodiment can vary an interleave ratio 302, such as a ratio of background tasks to interface tasks, represented by the Y-axis, as a function of the environmental condition magnitude 214 of FIG. 2 of the environmental condition 216 of FIG. 2 represented by the X-axis. By way of example, a trace 304 of the change in the ratio from low environmental condition magnitude 214 of the environmental condition 216 to a high environmental condition magnitude 214 of the environmental condition 216 (solid line), and from high environmental condition magnitude 214 of the environmental condition 216 returning to the low environmental condition magnitude 214 of the environmental condition 216 is represented by a minimum level 306.

In one embodiment, the change in a slope of the trace 304 can be based on a decrease threshold 305 that represents a trigger point to reduce the interleave ratio from an initial value 307. As the environmental condition magnitude 214 of FIG. 2 increases in severity as determined by the environmental condition magnitude 214 of the environmental condition 216, the interleave ratio can be curtailed. By way of an example, the reduction of the interleave ratio can be in a linear fashion or immediately reduced to a flat level. The example of FIG. 3 shows a linear reduction until an abort threshold 308, which represents the measure of the environmental condition magnitude 214 of the environmental condition 216 that can terminate the background tasks or fix them at a minimum level.

In one embodiment, when the environmental condition magnitude 214 of the environmental condition 216 exceeds a hysteresis threshold 310, a reduction in the magnitude of the environmental condition 216 does not increase the interleave ratio until an increase threshold 312 has been reached. The increase can take various forms. For example, the interleave ratio can increase from a hysteresis level 314 to a recovery level (threshold) 316, which is greater than the initial value 307. The interleave ratio can remain at the recovery level 316 until the background task has caught-up with the necessary capacity released to maintain proper operation.

In another embodiment, the interleave ratio can be reduced to zero when the abort threshold 308 is reached and can remain at zero until the environmental condition magnitude 214 of the environmental condition 216 is reduced to the increase threshold 312, which can be less than the decrease threshold 305. When the interleave ratio is adjusted, below the increase threshold 312, it can be adjusted to recovery level 316 in order to catch-up with the background task.

In an embodiment, an increase in the environmental condition magnitude 214 of the environmental condition 216 can

cause an increase in the interleave ratio beyond the decrease threshold **305**. The increase in the interleave ratio **302** can be necessary to counteract the effects of the environmental condition magnitude **214** in the interface tasks. In the space between the decrease threshold **305** and the hysteresis threshold **310** the ratio can increase in a linear or a non-linear manner. The interleave ratio **302** can be increased in response to the available capacity of the user space. By way of an example the less user capacity that remains, the higher the urgency of the background task to free sectors in the usable capacity.

It has been discovered that the electronic system **100** provides a dynamic adjustment in the interleave ratio **302** of the background tasks to interface tasks within the user capacity. In extreme cases the recovery from extended periods of the environmental condition magnitude **214** of FIG. 2 can impact the performance of interface tasks of the electronic system **100**.

The electronic system **100** has been described with module functions or order as an example. The electronic system **100** can partition the modules differently or order the modules differently. For example, the logical block address (LBA) number could be derived from the servo information read from the servo track **114** of FIG. 1A on the media **104** of FIG. 1A and passed through the read channel **202** of FIG. 2. This could represent a significant departure from current practices.

The modules described in this application can be implemented as instructions stored on a non-transitory computer readable medium to be executed by the control circuitry **138** of FIG. 1A in the electronic system **100**. The non-transitory computer medium can include the memory of the control circuitry **138** in the electronic system **100**. The non-transitory computer readable medium can include non-volatile memory, such as a hard disk drive, non-volatile random access memory (NVRAM), solid-state storage device (SSD), compact disk (CD), digital video disk (DVD), or universal serial bus (USB) flash memory devices. The non-transitory computer readable medium can be integrated as a part of the electronic system **100** or installed as a removable portion of the electronic system **100**.

Referring now to FIG. 4, therein is shown an exemplary block diagram of an apparatus configured to perform a background task **401** in an embodiment. The example of the background task **401** depicts an online region **402** of the media **104** and a background region **404**.

The online region **402** can be a data track **124** of FIG. 1A or multiple of the data tracks **124** being accessed through the system interface **140** of FIG. 1A. The online region **402** can contain valid data sectors **406** and invalid data sectors **408**. It is understood that the invalid data sectors **408** contain data that is no longer valid because a valid copy of the data is now stored elsewhere.

A background transfer **410** can be monitored by the control circuitry **138**, which can maintain a production counter **412** that monitors the successfully recovered units of the valid data sectors **406** recovered from the online region **402**. The control circuitry **138** can also maintain a consumption counter **414** to monitor skipped sectors **416** that were write aborts or verify failures. The control circuitry **138** can adjust the urgency of the background transfer **410**.

The control circuitry **138** can calculate a success ratio **413** by comparing the production counter **412** to the consumption counter **414**. The control circuitry can apply various thresholds to the success ratio **413** in order to manage the interleave ratio **302** of FIG. 3.

Referring now to FIG. 5, therein is shown a line graph **501** of performance of an embodiment of the electronic system

100 of FIG. 1A for managing background tasks based on an available capacity percentage **502**. The line graph **501** depicts the ratio of the interleave ratio **302** on the y-axis and the available capacity percentage **502** in the x-axis.

A first background task urgency **504** (which in this example is the interleave ratio at a particular remaining capacity point) can be dependent on the remaining available capacity percentage **502** operating under a low level of the environmental condition magnitude **214** of FIG. 2. As the available capacity percentage **502** decreases, the first background task urgency **504** can increase. While the first background task urgency **504** is shown as a linear increase, it is understood that the increase of the first background task urgency **504** can have other profiles.

A second background task urgency **509** (which in this example is the interleave ratio at a particular remaining capacity point) can be dependent on the remaining available capacity percentage **502** operating under a medium level of the environmental condition magnitude **214**. As the available capacity percentage **502** decreases, the second background task urgency **509** can increase. While the second background task urgency **509** is shown as a linear increase, it is understood that the increase of the second background task urgency **509** can have other profiles.

A third background task urgency **510** (which in this example is the interleave ratio at a particular remaining capacity point) can be dependent on the remaining available capacity percentage **502** operating under a high level of the environmental condition magnitude **214**. As the available capacity percentage **502** decreases, the third background task urgency **510** can increase. While the third background task urgency **510** is shown as a linear increase, it is understood that the increase of the third background task urgency **510** can have other profiles.

An idle range **506** can indicate that there is no execution of the background task **401** of FIG. 4. The idle range **506** can be in effect until the available capacity percentage **502** reaches 80%. In an operational range **508**, as the available capacity percentage **502** decreases from 80% to 10%, the increase in the first background task urgency **504** can be altered by the environmental condition magnitude **214** of the environmental condition **216** of FIG. 2. An adjusted urgency **511** can represent an example of a capacity trigger point for increasing the first background task urgency **504**, the second background task urgency **509**, and third background task urgency **510** independent of the environmental condition **216**.

In an urgency range **512**, when the available capacity percentage **502** is for example 10% or less, the first background task urgency **504**, the second background task urgency **509**, and third background task urgency **510** are set to a maximum of the interleave ratio **302** in order to regain needed capacity to maintain operation of the electronic system **100**. It is understood that the profile of the first background task urgency **504**, the second background task urgency **509**, and third background task urgency **510** are examples only and may differ depending on the environmental condition magnitude **214**, the available capacity percentage **502**, or the combination thereof.

Referring now to FIG. 6, therein is shown a line graph **601** of the interleave ratio **302** of the background tasks to interface tasks in the presence of the environmental condition **216**. The line graph **601** depicts a normal operating range **602** that represents a range of the environmental condition where the performance of background tasks can maintain the operational capacity of the electronic system **100** of FIG. 1A.

When the environmental condition **216** exceeds a capacity break **604**, the interleave ratio **302** can be decreased due to the

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diminishing benefit of the background task **401** of FIG. **4**. The capacity break **604** can represent the point at which the background task **401** consumes more of the available capacity percentage **502** of FIG. **5** than it can recover. Other step points can be calculated by the control circuitry **138** of FIG. **1A** based on the history of the environmental condition **216**, the success ratio **413** of FIG. **4**, or a combination thereof. It is understood that the step points for the capacity ranges can be different but are shown in the same relative location for simplicity. In addition, while step functions are shown, other functions may be used in various embodiments. For example, as previously shown in FIG. **3**, hysteresis control may be applied so that a different function may be applied when the environmental condition is returning from high to low.

The various lines **606**, **608**, **610** and **612** represent example response profiles of the system to increasing environmental condition (e.g., vibration) at different capacity levels, ranging from **606** representing an example response profile when the system has very low available media capacity remaining, to **612** representing an example response profile when the system has a relatively high available media capacity remaining.

A critically low available capacity response profile **606** can represent a response profile of the electronic system **100** of FIG. **1A** operating in the urgency range **512** of FIG. **5**, where the available capacity is extremely low. The critically low available capacity response profile **606** can have a constant slope across the environmental condition **216** due to the available capacity of the media **104** of FIG. **1A** being 10% or less. As the environmental condition **216** increases in severity, the critically low available capacity **606** can be held at a constant level in an attempt to regain as much of the capacity as possible through the continued performance of background tasks at a relative high level in relation to interface tasks. It is understood that the critically low available capacity **606** can have a different profile and FIG. **6** is just an example of the performance of an embodiment of the electronic system **100**. While the critically low available capacity response profile **606** is shown to have the interleave ratio **302** at substantially 0.95, this is an example only and the actual value of the interleave ratio **302** can differ.

A low available capacity response profile **608** can represent a profile of the electronic system **100** operating in the lower end of operational capacity range **508** of FIG. **5**, where the available capacity is getting low. The low available capacity response profile **608** can have a constant slope until the capacity break **604** due to the available capacity of the media **104** being, for example, between 11% and 20%. As the environmental condition **216** increases in severity, the low available capacity response profile **608** can be decreased in a step function, as shown, or decreased in a linear or non-linear function. It is understood that the low available capacity response profile **608** can have a different profile and FIG. **6** is just an example of the performance of an embodiment of the electronic system **100**. It is further understood that the range of the available capacity identified for the low available capacity **608** can be different.

A middle available capacity response profile **610** can represent a profile of the electronic system **100** operating in a middle range of the available capacity percentage **502** of FIG. **5**, where the available capacity is in, for example, a 40-60% range of the available capacity percentage **502**. The middle available capacity response profile **610** can have a constant slope until the capacity break **604** due to the available capacity of the media **104** being between 40% and 60%. As the environmental condition **216** increases in severity the middle available capacity **610** can be decreased in a step function, as shown, or decreased in a linear or non-linear function. It is

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understood that the middle available capacity **610** can have a different profile and FIG. **6** is just an example of the performance of an embodiment of the electronic system **100**. It is further understood that the range of the available capacity identified for the middle available capacity response profile **610** can be different.

A high available capacity response profile **612** can represent a profile of the electronic system **100** operating in a range of 61-80% range of the available capacity percentage **502**. The high available capacity response profile **612** can have a constant slope until the capacity break **604** due to the available capacity of the media **104** being between 61% and 80%. As the environmental condition **216** increases in severity the high available capacity response profile **612** can be decreased in a step function, as shown, or decreased in a linear or non-linear function. It is understood that the high available capacity response profile **612** can have a different profile and FIG. **6** is just an example of the performance of an embodiment of the electronic system **100**. It is further understood that the range of the available capacity identified for the high available capacity response profile **612** can be different.

The resulting method, process, apparatus, device, product, and/or system is straightforward, cost-effective, uncomplicated, highly versatile, accurate, sensitive, and effective, and can be implemented by adapting known components for ready, efficient, and economical manufacturing, application, and utilization.

These and other valuable aspects of an embodiment consequently further the state of the technology to at least the next level.

While the various embodiments have been described in conjunction with a specific best mode, it is to be understood that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations that fall within the scope of the included claims. All matters set forth herein or shown in the accompanying drawings are to be interpreted in an illustrative and non-limiting sense.

What is claimed is:

1. An apparatus comprising:

a media;

a head over the media;

a head actuation motor coupled to the head; and

control circuitry, coupled to the head actuation motor, configured to position the head; and

wherein the control circuitry is further configured to adjust a frequency of a background task based on a success ratio of the background task.

2. The apparatus as claimed in claim 1 wherein the control circuitry is further configured to adjust a frequency of the background task based on an unused portion of the media.

3. The apparatus as claimed in claim 1 wherein the success ratio is determined based on a space consumed in a process of performing the background task.

4. The apparatus as claimed in claim 3 wherein the space consumed is determined based at least in part on data on sectors skipped while writing due to the environmental condition.

5. The apparatus as claimed in claim 1 wherein the success ratio is further determined at least in part on sectors freed by the background task.

6. The apparatus as claimed in claim 1 wherein the success ratio is determined based on a rate of space consumed in the process of performing the background task.

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7. The apparatus as claimed in claim 1 wherein the success ratio is further determined based on a rate of sectors freed in the process of performing the background task.

8. The apparatus as claimed in claim 2 wherein the frequency of the background task is adjusted by comparing the success ratio to a threshold.

9. An apparatus comprising:

a media;

a head over the media;

a head actuation motor coupled to the head;

control circuitry, coupled to the head actuation motor, configured to position the head; and

an environmental sensor, coupled to the control circuitry, configured to measure a magnitude of an environmental condition;

wherein the control circuitry is further configured to:

perform a background task; and

adjust a frequency of the background task based on a magnitude of the environmental condition.

10. The apparatus as claimed in claim 9 wherein the control circuitry is further configured to adjust the frequency of the background task based on an unused portion of the media.

11. The apparatus as claimed in claim 9 wherein the background task includes garbage collection, file defragmentation, data compression, data encryption, or a combination thereof.

12. The apparatus as claimed in claim 9 wherein the environmental condition includes a vibration.

13. The apparatus as claimed in claim 9 wherein the environmental condition comprises a measure of a vibration, and the control circuitry is further configured to calculate an abort threshold of the background task based on a position error signal and the magnitude of the environmental condition.

14. The apparatus as claimed in claim 9 wherein the control circuitry is further configured to calculate a threshold of the frequency of the background task based on an unused portion of the media.

15. The apparatus as claimed in claim 9 wherein the control circuitry is further configured to apply a hysteresis of the frequency of the background task based on the magnitude of the environmental condition exceeds a recovery threshold.

16. The apparatus as claimed in claim 15 wherein the recovery threshold for applying the hysteresis is adjusted based on a history of the environmental condition.

17. The apparatus as claimed in claim 9 wherein the control circuitry is further configured to decrease the frequency of the background task if the magnitude of the environmental condition exceeds a severity threshold.

18. The apparatus as claimed in claim 9 wherein the control circuitry is further configured to increase the frequency of the background task if a free space generated by the background task exceeds a threshold.

19. A method of operating an apparatus, the method comprising:

flying a head over a media;

controlling a head actuation motor for positioning the head over the media; and

adjusting a frequency of a background task based on a success ratio of the background task.

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20. The method as claimed in claim 19 further comprising determining the success ratio by monitoring the space consumed by performing the background task.

21. The method as claimed in claim 20 wherein determining the success ratio includes counting sectors skipped while writing due to an environmental condition.

22. The method as claimed in claim 20 wherein determining the success ratio includes counting sectors freed by the background task.

23. The method as claimed in claim 20 further comprising determining the success ratio by monitoring a rate of space consumed in the process of performing the background task.

24. The method as claimed in claim 20 further comprising adjusting the frequency of the background task by comparing the success ratio to a threshold.

25. A method of operating an apparatus, the method comprising:

flying a head over a media;

controlling a head actuation motor for positioning the head over the media;

measuring a magnitude of an environmental condition by an environmental sensor; and

controlling a frequency of a background task based on the measured magnitude of the environmental condition.

26. The method as claimed in claim 25 further comprising adjusting the frequency of the background task based on an unused portion of the media.

27. The method as claimed in claim 25 wherein controlling the frequency of the background task includes controlling the frequency of garbage collection, file defragmentation, data compression, data encryption, or a combination thereof.

28. The method as claimed in claim 25 wherein measuring of the magnitude of the environmental condition includes measuring a vibration.

29. The method as claimed in claim 25 further comprising calculating an abort threshold of the background task based on a position error signal and the magnitude of the environmental condition.

30. The method as claimed in claim 25 further comprising calculating a threshold of the frequency of the background task based on an unused portion of the media.

31. The method as claimed in claim 25 further comprising applying a hysteresis of the frequency of the background task based on the magnitude of the environmental condition exceeding a recovery threshold.

32. The method as claimed in claim 31 further comprising adjusting the recovery threshold for applying the hysteresis based on a history of the environmental condition.

33. The method as claimed in claim 25 further comprising calculating a severity threshold for decreasing the frequency of the background task based on the magnitude of the environmental condition.

34. The method as claimed in claim 25 further comprising increasing the frequency of the background task based on the background task generating a free exceeding a threshold.

35. The method as claimed in claim 25 further comprising adjusting the frequency of the background task based on a ratio of the background tasks to interface tasks.

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